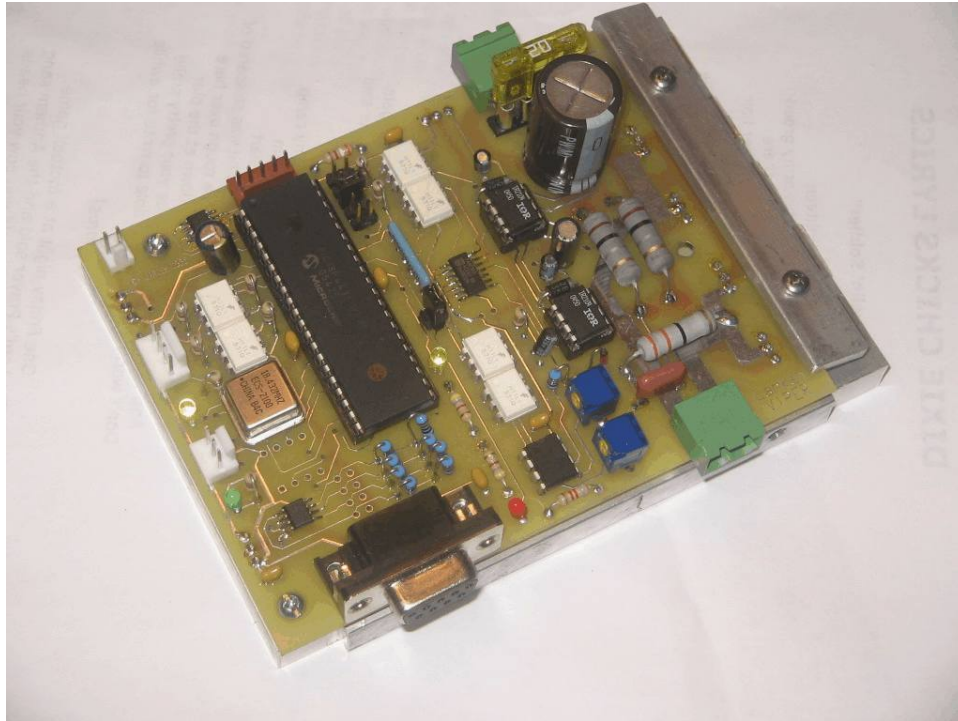


Viper DC servomotor drive Manual V1.2

Last edited Feb 27 2007



Full featured Industrial quality DC servodrive

Viper 100 80 Volt @ 20 amp model

Viper 200 180 Volt @ 20amp model

- 32 bit PID control with 16 bit RISC processor
- Step / Direction Control
- Warning output signals excessive motor load (slow down)
- Trip output signals drive has tripped
- Opto isolated power and control sections
- Onboard fuse (protect motor and for safety)
- 4X or 1X quadrature encoder counting
- Separate voltage regulator for encoder power
- 1,2,4,8 step multiplier (or any size)
- Settings are programmable by RS232
- Replaceable Power Mos-Fets and drivers
- Large main capacitor.
- Very efficient cool running drive.
- Stack-able card-type mounting
- Up to 4 motor configurations can be stored
- Jumper selectable motor rotation direction.

DISCLAIMER

Larken Automation assumes no responsibility for any personal injury or damage caused by use of its products.

Only electrically qualified personal should attempt to install the Viper drive.

High voltage can be lethal and proper safety procedures must be followed. Motors and drives should be properly grounded to prevent electrical shock.

Safety glasses should be worn ,since electrical components can explode causing injury or blindness

Copyright Notice

No part of this publication may be reproduced mechanically or electronically in any form without the prior written permission of Larken Automation Inc.

Firmware on the Viper drive is property of Larken Automation and reverse engineering or disassembly of the code is strictly forbidden.

The information in this manual is for informational use only, is subject to change without notice and should not be construed as a commitment by Larken. Larken assumes no responsibility or liability for any errors or inaccuracies that may appear in this document. Viper, Starcam and Starcnc are registered trademarks of Larken Automation Inc.

© October 2006, [Larken Automation Inc.](#)

Tech support

Contact

Larken Automation Inc.
5350 Canotek Unit 13
Ottawa, Ontario
Canada, K1J 9E1

Ph: (613) 746-5685
Fax: (613) 746-6451

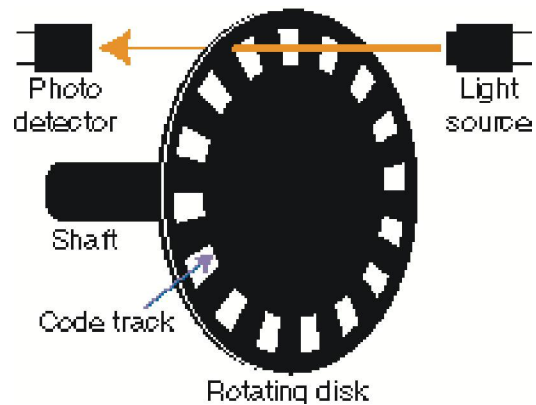
E-Mail: Larken@storm.ca

Website: www.LarkenCNC.com

DC Servo Motor Basics

The DC servo motor has an optical encoder that provides feedback to the controller. This typically can have from 100-5000 counts per turn.

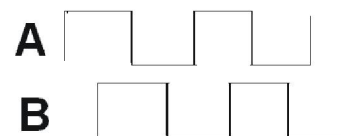
The most popular type of encoder is the optical encoder, which consists of a rotating disk, a light source, and a 2 photodetectors (light sensor). The disk, which is mounted on the rotating shaft, has many slots in it. As the disk rotates, these slots interrupt the light emitted onto the photodetector, generating a digital or pulse train.



The encoder has 2 square wave outputs. They are staggered at 90 deg. This way one is leading the other when turning CW and then trailing the other when turning CCW.

These are Channel A and B. The controller can tell which way the motor is turning by the A-B sequence. There may be an optional Index output also. (The index is not used by the Viper)

Encoder Outputs

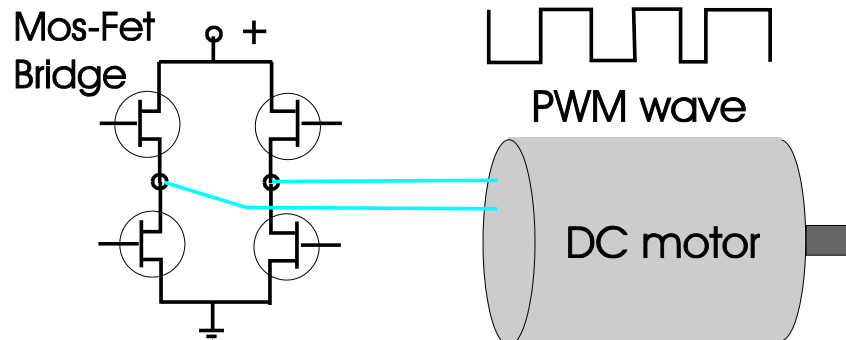


The DC servo motor has a Permanent Magnet outside (stator) and a wire wound armature. Carbon brushes connect the electrical power to the rotating armature. They can either have 2 or 4 brushes. A motor with 4 brushes gives a smoother motion.

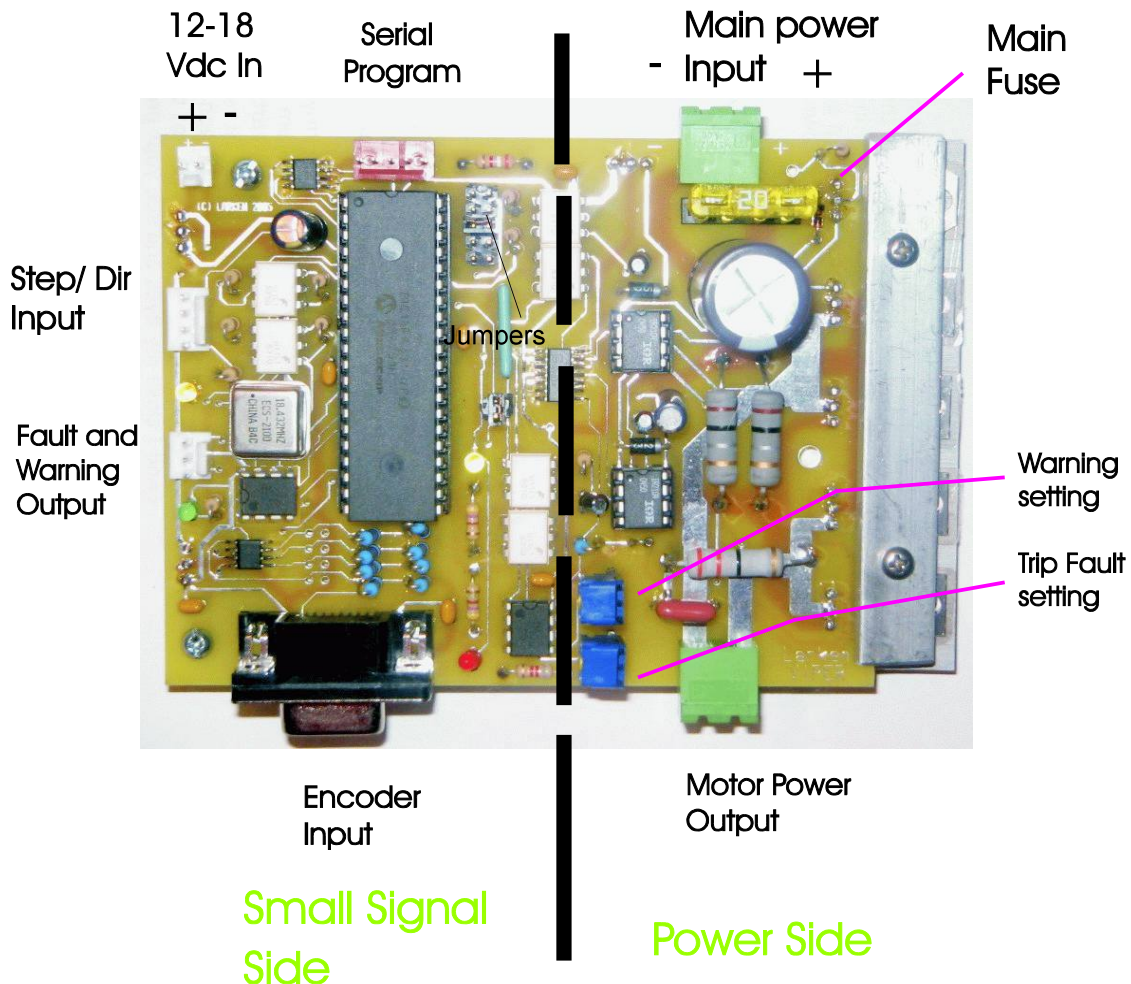
The motor also acts as a generator while spinning and under deceleration can force power back into the drive. A fast decelerating motor can increase the power-supply voltage above the drives maximum rating (80 or 160 volts) and cause drive failure.

A braking circuit can be added that loads the power-supply with a power resistor if the voltage rises above a preset limit.

The Viper drive uses a Mos-Fet or an IGBT bridge to drive the servo motor. The signal is Pulse Width Modulation or PWM with a frequency of 20,000 HZ



Viper Drive Connectors



Selecting a Powersupply Voltage

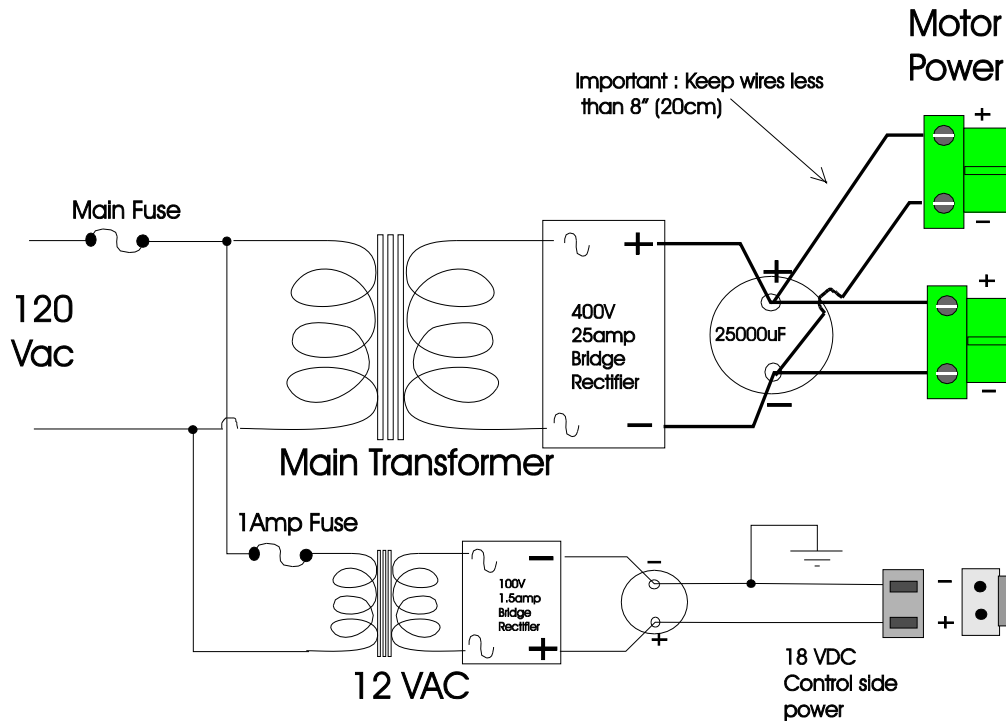
Motors typically specify a maximum DC voltage and maximum RPM. EG: and MCG ID34002 servo motor has a max DC voltage of 90 volts and runs 5000 rpm at 90 volts. These are maximum ratings, however you can set the powersupply lower than this to run the motor slower.

Setting a Safe Maximum RPM

You must decide what is the maximum RPM that you want the motor to run on your machine, incase of a possible drive failure. (This may put full power supply voltage to the motor and case a dangerous situation)

As a rule, set your powersupply to only about 10-20% higher than what you would need for your maximum rapid feed rate.

Viper Power supply recommended layout



The viper uses Isolated Power and small signal sections to eliminate ground problems associated with high power controls. This increases reliability and performance.

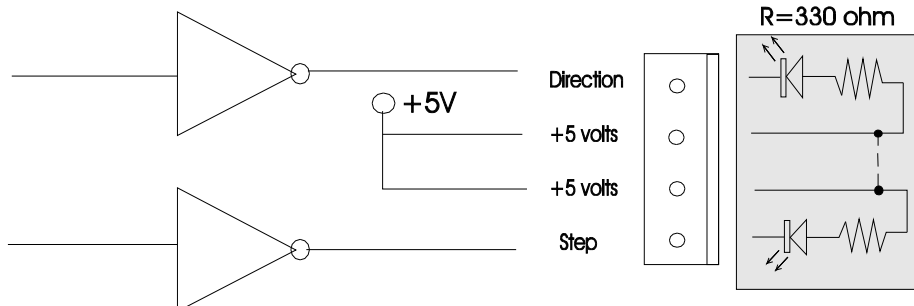
- The main transformer voltage is to match motor voltage requirements.
($DC\ volts = AC\ voltage \times 1.414$)
- Keep the main DC power wires short, typically 8" (20cm) or less.
- The 12volt may be powered from the main transformer as a 2nd winding, but must be isolated .
- The high power side of the viper is isolated from ground and small signal side. It is best to keep this side isolated
- The heatsink is isolated from the viper circuit.
- The Viper drive is designed to be mounted vertically with its encoder and motor connectors through the back of the cabinet. The mounting screws are 8-32

Note: The small signal side will be grounded the to chassis ground by encoder connector (9 pin D-type) when mounted to a case.

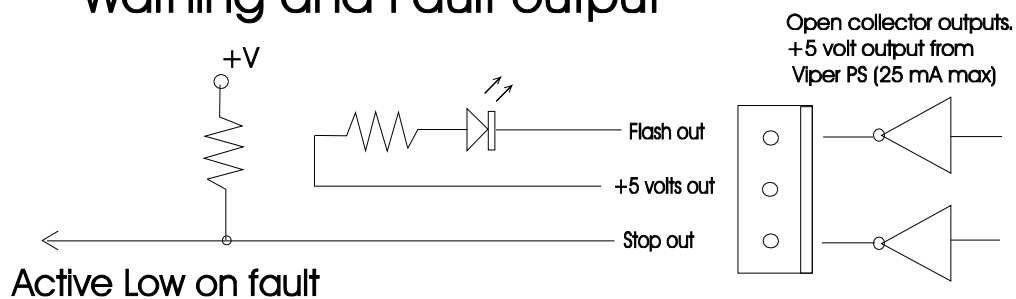
Warning Voltages over 80 volts can be lethal. Be sure to ground the motor frame when testing and have viper drive mounted in grounded chassis when testing.

Viper Interface connections

Step and Direction interface

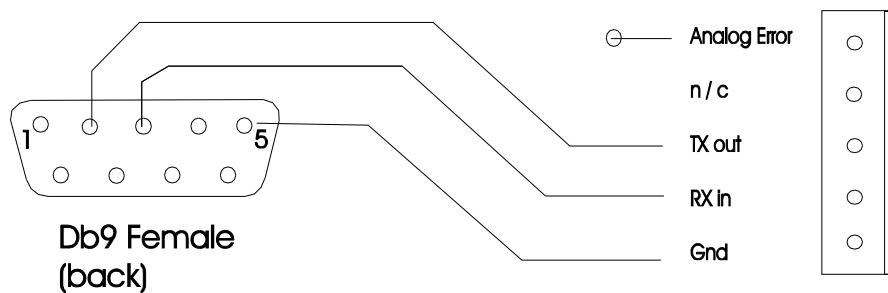


Warning and Fault output



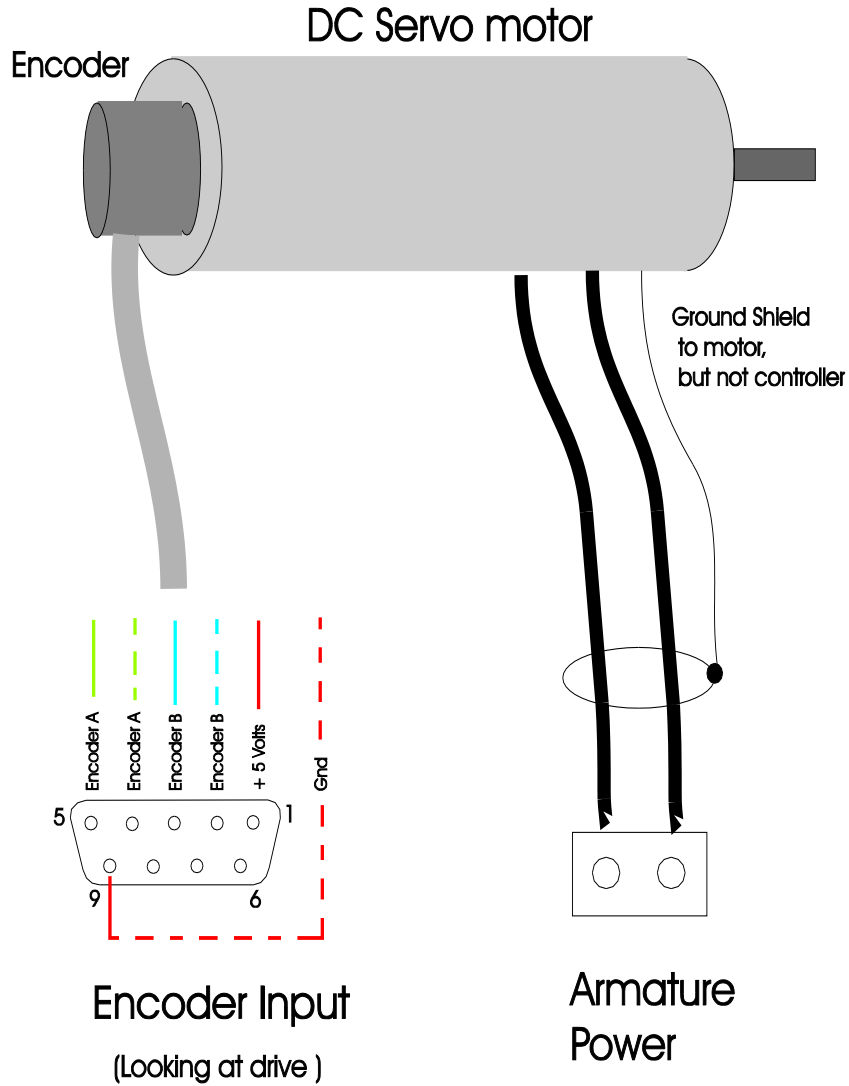
Theses outputs can be ganged to multiple drives (Negative is common with Input power Gnd)

Rs232 serial interface and Error monitor



The RS232 cable is available from Larken Automation

Motor Encoder and Power connections



- Use twisted pair network cable for encoder cable. Stranded wire (not solid)

Note :

Diagram shown for a differential encoder. For a single ended encoder, use just one connection per channel. Use (stranded) twisted pair cable for encoder wire.

Use shielded wire if available. Connect the shield on *one end only* to avoid current flowing in shield.

Understanding PID control

PID stands for *Proportional-Integral-Derivative*. These are the 3 adjustable factors that make the controller able to keep the motor stable in the servo loop. All factors are adjustable in magnitude by the user. A servo works by constantly correcting the position error. The error is the difference between the encoder position and the step/dir counter.

The **Proportional term** (KP) directly outputs voltage to the motor in opposite proportion to the error. By its self though, the motor will just bounce back and forth in oscillation as this is factor increased.

The **Derivative term** (KD) keeps the loop stable by comparing the latest error amount to the last error amount. If it sees the error getting worse (over the last 2 loops), then it increases the power in the opposite direction to correct. If it sees the error getting less, then it reduces the correcting power to the motor.

The **Integral term** (KI) is a correcting factor that helps correct a positioning error by increasing the correction higher as time goes by. EG if a load was hard to move and caused a steady error to the left, the Integral would push harder and harder to the right on each loop of the servo timing, building up as time goes by. As the load corrected, the servo would reduce pushing to the right.

Servo Loop

The controller runs a software loop which reads the encoder and calculates a new output power and polarity to the motors thousands of times a second.

LOOP

Read encoder (motor position)

Read commanded position (from step and direction input)

Subtract the two to get the error.

Calculate $KP * \text{error}$ = proportional result

Calculate $KI * \text{Integral error sum}$ = Integral result

Calculate $KD * \text{error}(T) - \text{error}(T-1)$ = Derivative result

Add all 3 results to create the output correction value

Convert to a PWM duty cycle and output to motor

JUMP to LOOP START

The loops per second is an other programable setting in the Viper drive. This has a big effect in matching the mechanical reaction time of the motor. Generally the heavier the motor armature, the slower the loop timing needed.

Note: a motor can only respond so fast to changes in position correction.

Some drive manufacturers claim very high loop times of millions of loops per second. A typical motor can only change its acceleration/ deceleration velocity at a rate of a few hundreds of a second. Also if the PWM frequency is 20,000 cycles per second. The loop time has to be slower than the PWM.

Tuning the PID loop

Note: Be sure to have the motor mounted or clamp the motor to a table before tuning! The motor can react very violently and cause damage or personal injury.

Note: Remove the bank jumpers (Bank 0) so the drive runs in **current limited mode** when checking the wiring on a motor for the first time.

Start with $KP = 100$, $KI = 0$, $KD = 200$ and $Loop = 4$

- 1) Increase KP, 50 points at a time until the motor gets stiffer.
- 2) Keep increasing KP until the motor starts to oscillate when disturbed (bump the shaft or accelerate back and forth).
- 3) Adjust the loop time parameter one unit at a time either way until the motor reduces its oscillation. (The range of the loop parameter is 1-10) After this is set you shouldn't need to change this parameter.
- 3) Then increase KD until the motor is stable. KD usually ends up about 2 times KP.
- 4) The KI term is usually a very small value (2-20) since it adds to itself rapidly. The KI should be set to zero until KP and KD have been adjusted.
- 5) Save the parameters by using the 's' command.

The power supply voltage also plays a part to the tuning. For any given motor, KP and KD will need to be less when the power-supply voltage is high, compared to if the voltage was lower. This is because a certain gain produces a duty cycle, and the actual voltage to the motor is the power-supply voltage * duty cycle.

Summary

- KP Sets the stiffness of the motor.
- KD settles the oscillation and overshoot.
- The Loop time needs to be matched to the motor and load early in the tuning when the KP and KD are at lower values, but can be re-adjusted at final tuning.
- KI can be added at the end to improve low-speed holding error.

Using Banks for storing multiple configurations

The Viper drive allows you to setup 3 different preset configurations. This allows the drive to be Jumper selectable in the field for your most common motors.

When you power-up the drive the current bank selected will be the one you are tuning in this session. When done tuning that bank, Save the parameters to the EEprom and then you can turn the drive off.

Testing a new motor for the first time (Bank 0)

When Bank 0 (no jumpers) is selected the Viper will limit the power to the motor by 60% to protect the drive from over-current when setting up a new motor.

It's a good idea to put a 10ohm 10 watt resistor in series with the motor power (when testing only) since if an encoder is not wired correctly the motor can violently oscillate possibly causing drive damage by excessive current. Remove the resistor after the wiring is confirmed correct.

You can use Bank 0 to test and program parameters for the motor, then write them down and enter them in an other bank.

Only Bank 0 is current limited. The default KP, KI and KD are set to low values in this bank for testing motors. These parameters can be changed and saved, but current limit will always be in effect.

Testing the Encoder with Main power off

You can test the encoder to make sure the Viper is reading it properly before testing with power to the motor.

Disconnect the main motor power connector, and just power the control side of the Viper with the 12volt supply. With the RS232 connected, use the 'm' command to read the encoder position. Turning the motor one way should increase the encoder counter and the other way should decrease it into negative values. Note: this register is displayed in 16 bit Hex, so negative starts from FFFF and gets smaller.

Also you can set the range command (r) to the number of motor counts of error before the drive faults and flashes the LED.

Motor runs away when turned on

If when setting up the motor for the 1st time and it runs on when power is applied, Reverse the power connections to the motor.

The motor should 'hold' when power is applied if correctly wired.

Adjusting Current limit and Current warning

There are two trim pots on the Viper. The one closest to the edge of the board is the Current Trip setting, and the other is the Current Warning setting.

Turning these pots (potentiometers) CW increases the amount of current allowed to the motor, and turning them CCW makes them trip at a lower current.

NOTE : use a plastic or non metallic screw driver to adjust these pots, to prevent shorts or electrical shock if the screwdriver touches the PCB board.

Adjusting Current limit and Current warning (continued)

To start adjust the both pots full CW. With the motor holding, apply a twisting to the shaft to simulate an excessive load of the amount that you want to trip the drive. While holding the motor in this position, adjust the trip pot CCW until the red LED lights. Holding the light on for 2 seconds will make the drive cut the power to the motor and flash the Fault light rapidly. (Disconnect the 12volt to the control side to Reset power to the drive to reset the trip fault).

Do the same to adjust the Warning limit pot with less of a load on the motor. The yellow LED is used to set this current

The warn doesn't trip the drive, but flashes slowly the Fault light and holds down the 'Stop' output if the current stays high for more than 2 seconds. When the load reduces, the error goes away.

The Software error range setting causes the Fault light to flash very slowly and holds down the 'Stop' output as well if the motor goes out of range for more that 2 seconds. When the motor error is less than the range setting the error goes away.

The Viper has 2 output signals. One is to power a flashing LED on the front panel of the controller, and the other should be connected to your Estop signal to stop the motion commands. These are open collector outputs and can be parallel connected to multiple Viper drives.

When an error is flashed, the Viper will hold down the Estop signal until the error is removed. You can add a Fault override switch (normally closed) in this estop line to allow the operator to jog the machine while holding the switch to recover from a warning error.

LED flashing errors

- Slow flash - Motor is out of position range (motor power still enabled)
- Medium flash - Warn current reached (motor power still enabled)
- Fast flash - Current trip reached and Output power has been disabled

Viper command set

The Viper is programmed by connecting to a PC using the serial RS232 port. A cable can be made as described in the above diagram.

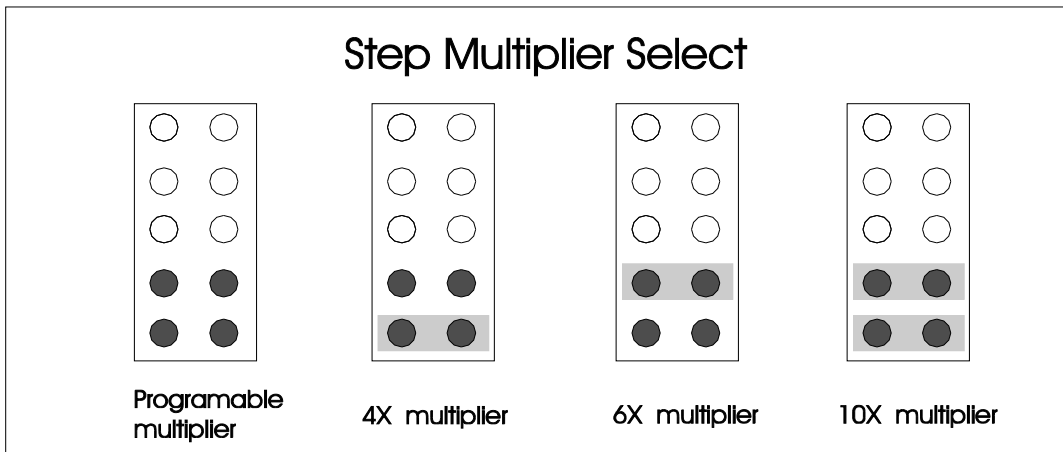
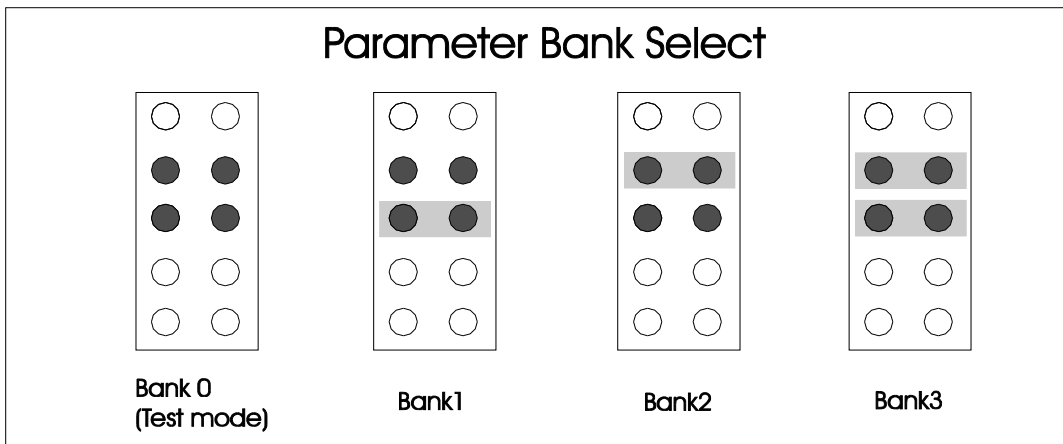
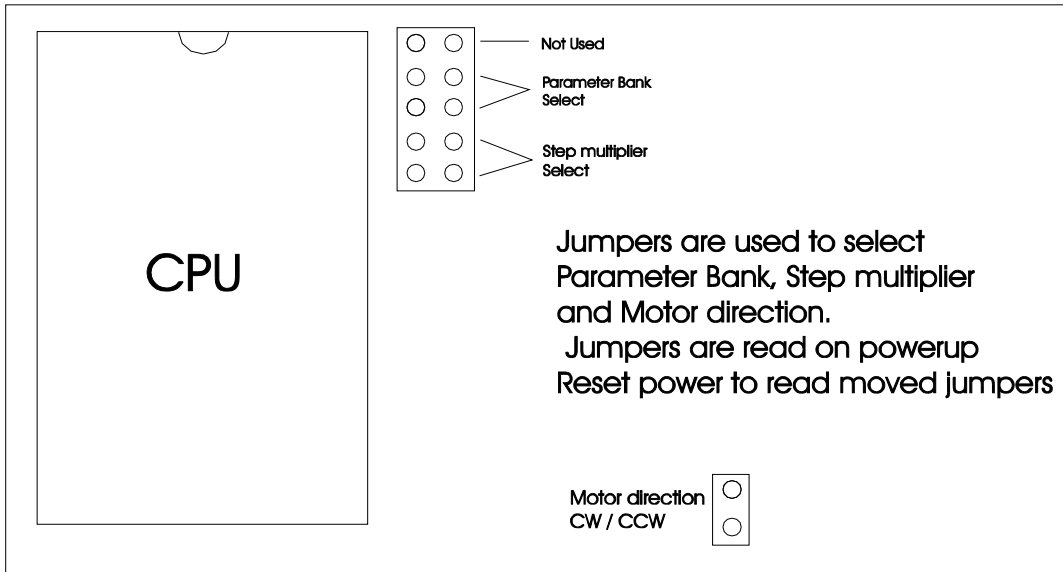
Run the windows **Hyper Terminal** program from the Accessories group. Create a New session using Comm1, 9600 baud, 8,1,N.

All commands are entered in lowercase and followed by a 'carriage return' <cr>.

Command	Description	Example
Data entry		
p nnnn	Enter Proportional term	p800<cr>
I nnnn	Enter Integral term	I6<cr>
d nnnn	Enter Derivative term	d1400<cr>
j nn	Enter step size (jump)	j3<cr>
l nn	Enter Loop term	l4<cr>
n nn	Enter number of bank	b3<cr>
r nnnn	Enter error range limit	r64<cr>
Read data		
e	Get servo error in Hex	e<cr> -00A1
v	Get software version	v<cr> V2
?	Get current settings in Hex	?<cr> Returns N, P, I, D, L, data
m	Get motor encoder and step position	m<cr> m00F0 s00F1 (hex result)
Other		
o	Disable power to motor	o<cr>
x	Enable motor power	x<cr>
z	Set defaults and save to EEprom	z<cr>
s	Save settings to EEprom	s<cr>

Notes <cr> = enter. Only change Bank# if you are entering data for banks other than the bank selected by the jumper (for saving).

Selecting Jumpers



Component Data

Parts supply

Fuse 5, 10, 15 or 20 amp automotive type. Select the fuse amperage to protect motor winding or machine from damage incase of drive failure.

Connectors

(Available from Digikey www.Digikey.com 1-800-344-4539)

Digikey Part #	Description
WM2200-ND	tiny Crimp term .1" for block
WM2000-ND	Housing 2 Pin .1" (for 15 volt power)
WM2001-ND	Housing 3 Pin .1" (for fault output)
WM2002-ND	Housing 4 Pin .1" (for step/ direction)
WM2003-ND	Housing 5 Pin .1" (for RS232)

A Crimping tool for .1" block connectors is highly recommended

Output and motor power (Viper 100)

277-1011-ND Pheonix 2 pin plug green power

Output and motor power (Viper 200)

277-1463-ND Pheonix 2 pin plug green power